Does uncertainty affect economic growth?

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AN EMPIRICAL ANALYSIS

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1. Introduction

Following the seminal paper by Barro (1991), there has been increasing interest in empirical research relating to growth theory. The motivation of this strand of literature has been to isolate the variables which have a robust effect on economic growth in a cross-section of countries; see, in particular, Levine and Renelt (1992), King and Levine (1993), Sala-i-Martin (1997a and 1997b) and Sachs and Warner (1997). A large set of possible explanatory variables is constructed and regression analysis is used to identify the variables which are statistically significant in explaining economic growth. Although a common problem with this type of empirical work has been to establish the robustness of the empirical growth equations, Levine and Renelt (1992) and Sala-i-Martin (1997a, 1997b) provide some useful stability tests for the reliability of the results.

None of the recent empirical growth studies considers the effect of uncertainty on economic growth. This is a remarkable empirical vacuum, given that there is now a vast theoretical literature that emphasizes the importance of uncertainty for economic growth. Most of these theoretical studies examine how uncertainty affects private investment, and hence indirectly economic growth; see, for instance, Lucas and Prescott (1971), Arrow (1968), Abel (1983), Bernanke (1983), Caballero (1991), Abel and Eberly (1994) and Dixit and Pindyck (1994). There are also lively debates on the impact of inflationary uncertainty on economic growth; the effects of exchange rate variability on trade and growth; and the consistency and predictability of fiscal policy in the long run. In addition, some studies examine the effects of uncertainty on investment at a firm level (for a survey, see Leahy and Whited (1996)). At the macro level the few examples we are aware of are the studies of Aizenman and Marion (1993) and Brunetti and Weder (1998). Aizenman and Marion (1993) look at the effects of macroeconomic uncertainty on private investment for a cross-section of countries. Brunetti and Weder (1998) examine the effect of institutional uncertainty on total investment. Both studies find evidence of a negative effect of uncertainty on investment. However, the studies do not present a robustness analysis, casting doubts on the reliability of the results.

This paper presents evidence on the effects of uncertainty on economic growth by performing a Barro-type growth regression in which different uncertainty measures are taken into account. We include measures of uncertainty related to fiscal policy, financial markets and goods prices. We use a sample of about 100 countries over the years 1970-1995. The main innovative feature of the paper is that it uses an extreme bounds stability analysis (EBA) and a stability analysis in line with Sala-i-Martin (1997a, 19997b) in order to test for the reliability of the regression outcomes, thus heralding the application of this battery of techniques to the literature on uncertainty and economic growth.

The remainder of the paper is structured as follows. Section 2 explains how we measure uncertainty. Section 3 gives the regression results and presents the stability tests. Section 4 concludes.

2. The measurement of uncertainty

In empirical analysis the measurement of uncertainty is an important issue. The literature distinguishes between different approaches (see Bo (1998)). The most common approach starts by specifying and estimating a forecasting equation for the stochastic variable under consideration. The standard deviation of the residuals from this regression equation are then used as proxy for uncertainty (see *e.g.* Aizenman and Marion (1993), Ghosal (1995), and Ghosal and Loungani (1996)). Mostly, a first, or higher autoregressive process, possibly extended with a time trend, is formulated in order to estimate the equation used to determine expected outcomes.

In this paper, the forecasting equation we use is a second-order autoregressive process of the form

$$P_t = a_1 + a_2 T + a_3 P_{t-1} + a_4 P_{t-2} + e_t \qquad (1)$$

where P_t is the variable under consideration; T is a time trend; a_1 is an intercept; a_2 and a_3 are the autoregressive parameters; e_t is an error term.

The equation is estimated for each country over the sample period (1970-1995). The basic data set consists of 138 countries (the countries in the Barro-Lee data set), and contains some developed and many developing countries. For each country, uncertainty with respect to an explanatory variable (*e.g.* P) is measured by the standard deviation of the residuals.

We concentrate on 6 types of uncertainty (see Appendix for a list of variables):

EBUD: uncertainty with respect to the budget deficit (P variable = BUDDEF)

ETAX : uncertainty with respect to taxes (P variable = TAXGDP)

EGOVC: uncertainty with respect to government consumption (P variable = GOVCGDP)

EEXP: uncertainty with respect to export sales (P variable = EXPGDP)

ERINTR: uncertainty with respect to real interest rate (P variable = RINTR)

EINFL: uncertainty with respect to inflation (P variable = INFL)

The uncertainty measures proxy for export uncertainty (EEXP), uncertainty with respect to government policies (EBUD, ETAX and EGOVC) and price uncertainty (ERINTR and EINFL).

3. Regression results and stability analyses

We estimate the following cross-section regression:

$$PCGROWTH = \alpha_j + \beta_{ij}\, I + \beta_{mj}\, M + \beta_{zj}\, Z_j + \mu \qquad (2)$$

where PCGROWTH is the per capita growth rate of GDP; *I* is a vector of fixed variables always included in the regressions; *M* is the variable of interest, namely one of the uncertainty measures; Z_j is a vector of three variables taken from a pool of N available domestic and international macroeconomic variables identified by past studies as being potentially important explanatory variables of economic growth. For each model j, we are interested in estimates of the coefficient β_{mj} and the corresponding standard deviation.

We proceed by first deciding which variables are always included in the regression (the vector of variables *I*). We then include the uncertainty proxies (the *M* variables) one by one and test for the robustness of the results. Based on Sala-i-Martin (1997a, 1997b) and many other studies, the initial level of per capita GDP (*GDPPC*) and the initial primary -school enrolment rate (*PRENR*) are always included in the regressions. *GDPPC* is included to account for the conditional convergence effect. The sign is expected to be negative. *PRENR* proxies for the initial stock of human development. The sign is expected to be positive. It should however be noted that, although almost all growth studies include a measure of human development, this variable is not always robust. Based on King and Levine (1993) we also include the money and quasi-money to GDP ratio (*MGDP*). It measures financial development of a country. Finally, we also include the investment to GDP ratio (*INVEST*). A word is in order with respect to the investment share. Most growth regressions show that *INVEST* significantly affects economic growth. However, if the investment to GDP ratio is introduced, the interpretation of a significant coefficient for a given variable differs from a significant coefficient for that variable when the investment rate is not introduced. In the first case, the variable is said to affect growth via the "level of efficiency" whereas in the latter case it is unclear whether it affects growth via investment or via efficiency (see also Sala-i-Martin, 1997b). For this reason, we perform a series of estimations in which *INVEST* is not included and a set of estimates in which *INVEST* is always included. Hence, the *I* vector contains *GDPPC, PRENR, MGDP* and *INVEST* or only *GDPPC, PRENR* and *MGDP* .

Our empirical strategy is as follows. We start with an estimate in which all above mentioned *I* variables are included. The results are presented in column 1 in Table 1(with the investment share) and column 1 in Table 2 (without the investment share). The equations show that the *I* variables are significant. Next, we add, one by one, the different uncertainty measures. These results are shown in columns 2-7 in the Tables 1 and 2. The tables clearly show that five of the six uncertainty variables affect economic growth. With the exception of uncertainty with respect to the real interest rate, all uncertainty measures have a significant and negative effect on per capita growth. This applies both for the model in which

INVEST is taken into account as well as the model in which *INVEST* is not included. This suggests that uncertainty not only affects economic growth via the investment level, but also via the level of efficiency.

<insert Tables 1 and 2 about here>

To test the reliability of the above results, a group of domestic and international macroeconomic variables is added to the estimations as presented in Table 1 and Table 2. The selection of the set of domestic and international macroeconomic variables, out of which the *Z*-variables are drawn, is based on those identified by Sala-i-Martin (1997a) as being important for economic growth. The following variables are included in the various models estimated:

1. Political variables: We consider an index for civil liberties (*CIVIL),* an index of political rights (*PRIGHTS),* a war dummy (*WARDUM*) and a measure of political instability (*PINSTAB*).

2. Policy variables to measure market distortions: We use the black market premium (*BMP*), the inflation rate (*INFL*) and the standard deviation of inflation (*STDINFL*).

3. Measures of openness: We have included the trade to GDP ratio (*TRADE),* an alternative measure of free trade openness (*FREEOP)* and the export to GDP ratio (*EXPGDP*).

4. Financial development indicators: We include some other proxies for financial development. We include credit to the private sector as a percentage of GDP (*CREDITPR*), the deposit rate (*DEPR*), the real interest rate (*RINTR*) and the real exchange rate (*REXCHR*).

5. Indicators of capital flows: We include the foreign aid to GDP ratio (*AIDGDP*), bank lending as a percentage of GDP (*BANKL*) and foreign direct investment as a percentage of GDP (*FDI*).

6. Foreign debt indicators: We include the Debt to GDP ratio (*DEBTGDP*) as well as the Debt service to GDP ratio (*DEBTS*).

7. Some other policy variables: The government budget deficit as a percentage of GDP (*BUDDEF)*, government expenditures as a percentage of GDP *(GOVCGDP*), taxes as a percentage of GDP (*TAXGDP*).

Hence, the total pool contains 22 variables. We perform, for each uncertainty measure, regressions for all possible combinations of three out of the above-presented set of 22 variables. This implies that 1540 (22!/(19! 3!)) estimates have been done per uncertainty measure.

The procedure of the EBA is as follows. For each regression *j*, we find an estimate β_{mj} and a standard deviation σ_{mj}. The lower extreme bound is the lowest value of $\beta_{mj} - 2\sigma_{mj}$, whereas the upper bound is $\beta_{mj} + 2\sigma_{mj}$. If the upper extreme bound for variable *M* is positive and the lower extreme bound is negative (*i.e.* the sign of the coefficient β_{mj} changes), then variable *M* is not robust according to the *EBA* analysis.

The results of the *EBA* analysis are given in the columns *High* and *Low* in Table 3 and Table 4. It can be seen that in all cases there is a sign switch, so that none of the uncertainty measures robustly affects economic growth when the *EBA* analysis is used. However, this is not remarkable given the fact that 1540 estimates per uncertainty measure are done, and the *EBA* analysis implies that, if in only one of the 1540 regressions the measure is not significant, the analysis indicates "not robust." For this reason, Sala-i-Martin (1997a and 1997b) comes up with an alternative stability test. His analysis comes down to looking at the entire distribution of the coefficient β_m, instead of a zero-one (robust-fragile) decision and calculating the fraction of the cumulative distribution function lying on each side of zero. By assuming that the distribution of the estimates of the coefficients is normal and calculating the mean and the standard deviation of this distribution, the cumulative distribution function (*CDF*) can be calculated. His methodology starts by computing the point-estimates of β_{mj} and the standard deviation σ_{mj} per regression. The mean estimate of the coefficient and the average variance are then calculated as

$$\overline{\beta_m} = \frac{\Sigma\, \beta_{mj}}{n}$$

$$\overline{\sigma^2_m} = \frac{\Sigma\, \sigma^2_{mj}}{n}$$

The mean estimate of the coefficient and the average standard error are the mean and the standard deviation of the assumed normal distribution. In Table 3 and Table 4 the mean estimate is given by the column *Coef*, the mean standard deviation by the column *St error*. Finally, by using a table for the (cumulative) NORMAL distribution, it can be calculated which fraction of the cumulative distribution function is on the right or left hand side of zero. In the tables below CDF denotes the largest of the two areas. If *CDF* is above 0.95 it is concluded, according to this analysis, that the uncertainty measure has a robust effect on economic growth.

<Tables 3 and 4 about here>

Using the latter stability analysis, it appears that four of the uncertainty measures, EBUD, ETAX, EGOVC and EEXP have a robust and negative effect on per capita economic growth. This applies both for the model in which *INVEST* is included and for the model in which it is not included. ERINTR and EINFL do not have a robust effect on economic growth.

Finally, we present in the last columns of both tables the percentage of all regressions for which the uncertainty measure is significant at the 90% level. The four "robust" uncertainty measures have a significant effect on per capita growth in the majority of the regressions. It also appears that in more than one-third of the regressions EINFL has a significant negative effect, suggesting that also inflationary uncertainty is important for explaining economic growth. *ERINTR* is only significant in about 10 percent of the regressions.

4. Summary and conclusion

This paper examines the effect of different uncertainty measures on per capita GDP growth for a cross-section of countries for the 1970-1995 period. The results clearly confirm the relevance of uncertainty for economic growth. Four out of the six measures for uncertainty considered appear to have a robust and negative effect on economic growth. The uncertainty measures directly related to government policies, *i.e.* the uncertainty with respect to government expenditures, taxes and the budget deficit, are highly significant and have a robust negative effect on per capita growth. Sales uncertainty, as measured by exports, also has a robust and negative effect on economic growth. We also find some evidence for a significant and negative effect of inflation uncertainty on economic growth. Our results support the notion that predictability of government policy and credibility of governments stimulate economic growth by lowering uncertainty. This typically holds for fiscal policy, but also for monetary policy. Policy that stabilizes trade also helps in creating more growth per capita. These outcomes underline the utmost importance of a stable macro economic environment for per capita economic growth.

Appendix: List of Variables

AIDGDP = development aid as a percentage of GDP

BANKL = bank and trade related lending as a percentage of GDP

BMP = black market premium, calculated as (black market rate/official rate)-1.

BUDDEF = overall budget deficits, including grants as a percentage of GDP

CIVLIB = index of civil liberties

CREDITPR = credit to the private sector as a percentage of GDP

DEBTGDP = the external debt to GDP ratio

DEBTS = total external debt service as a percentage of GDP

DEPR = the deposit rate (%)

EBUD = uncertainty with respect to government budget deficit

EEXP = uncertainty with respect to exports

EGOVC = uncertainty with respect to government consumption expenditures

ERINTR = uncertainty with respect to real interest rate

ETAX = uncertainty with respect to taxes

EXPGDP = exports of goods and services as a percentage of GDP

FDI = foreign direct investment as a percentage of GDP

FREEOP = measure of free trade openness (calculates as 0.528-0.026 log(AREA) –0.095 (DIST), where

AREA = size of land and DIST = average distance to capitals of world 20 major exporters.

GDPPC= GDP per capita in 1970

GOVCGDP = government consumption as a percentage of GDP

INFL = the annual inflation rate

INVEST = average investment to GDP ratio over 1970-1995 period

MGDP = average money and quasi money to GDP ratio over the 1970-1995 period

PCGROWTH = average real per capita growth rate over 1970-1995 period.

PINSTAB = measure of political instability

PRENR = primary school enrollment rate in 1970

PRIGHTS = index of political rights

REXCHR = real exchange rate

RINTR = real interest rate (%)

STDINFL = the standard deviation of the annual inflation rate, calculated from the inflation figures

TAXGDP = total taxes as a percentage of GDP

TRADE = exports plus imports to GDP. This variable measures the degree of openness.

WARDUM = dummy variable giving a one to countries that participated in at least one external war during

the period 1960-1985, and a zero to all other countries.

The source for all variables is World Development Indicators, 1997 (World Bank, available on CD-Rom), except for BMP, CIVLIB, FREEOP, PINSTAB, PRIGHTS and WARDUM who are obtained from the Barro-Lee data set, and the uncertainty measures who are calculated by the authors. The variables coming from the Barro-Lee data set refer to averages for the 1970-1990 period. Unless otherwise stated, all other variables refer to averages over 1970-1995 period.

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Table 1: Uncertainty and Economic Growth: base model 1

	1	2	3	4	5	6	7
PRENR	0.010 (2.12)	0.004 (0.56)	0.011 (2.11)	0.002 (0.33)	0.007 (1.50)	0.009 (1.88)	0.012 (2.42)
GDPPC	-9.21 E-05 (-2.91)	-1.35 E-05 (-0.39)	-0.0001 (-3.77)	-4.72 E-05 (-1.97)	-8.51 E-05 (-4.39)	-8.85 E-05 (-2.60)	-9.37 E-05 (-2.99)
MGDP	0.038 (4.81)	0.043 (5.00)	0.033 (4.25)	0.031 (3.85)	0.036 (4.39)	0.035 (4.10)	0.035 (4.23)
INVEST	0.106 (3.15)	0.147 (3.85)	0.147 (4.30)	0.131 (3.92)	0.142 (4.02)	0.112 (3.31)	0.105 (3.07)
CONST	-3.006 (-5.04)	-2.792 (-4.29)	-2.792 (-4.31)	-2.036 (-3.43)	-2.557 (-3.73)	-2.908 (-4.85)	-2.908 (-4.84)
Ad. Var.		EBUD	ETAX	EGOVC	EEXP	ERINTR	EINFL
		-0.360 (-3.37)	-0.674 (-3.14)	-0.477 (-4.48)	-0.293 (-3.45)	-0.006 (-0.57)	-0.0009 (-1.98)
R^2	0.46	0.56	0.53	0.54	0.53	0.45	0.48
Obs	96	72	90	96	96	86	96
JB	1.27	0.21	0.91	0.85	0.28	1.37	0.28
MDEPV	1.27	1.15	1.28	1.27	1.27	1.28	1.27
SDDEPV	1.93	2.02	2.08	1.93	2.11	1.90	2.11
F	20.86	19.16	21.10	23.64	22.85	15.03	18.45

Note: dependent variable: PCGROWTH. MDEPV = mean of the dependent variable; SDDEPV = standard deviation of the dependent variable; R^2 = adjusted R^2; F = F-statistic. The t-values are between parentheses. t-values are based on White heteroskedasticity-consistent standard errors (this applies to all tables). JB = Jarque-Bera normality test. The test result suggests that for all estimated models the residuals be normally distributed. Obs. = amount of observations.

Table 2: Uncertainty and Economic Growth; base model 2

	1	2	3	4	5	6	7
PRENR	0.013 (2.60)	0.009 (1.44)	0.015 (2.79)	0.007 (1.28)	0.012 (2.29)	0.012 (2.35)	0.015 (2.87)
GDPPC	-0.00012 (-3.47)	-4.21 E-05 (-1.02)	-0.00013 (-3.85)	-8.73 E-05 (-3.36)	-0.00012 (-4.83)	-0.00011 (-3.06)	-0.00012 (-3.59)
MGDP	0.054 (6.54)	0.061 (5.56)	0.050 (6.31)	0.052 (6.34)	0.056 (6.86)	0.052 (6.15)	0.051 (6.22)
CONST	-1.391 (-3.60)	-0.611 (-1.21)	-0.641 (-1.25)	-0.362 (-0.69)	-0.779 (-1.33)	-1.185 (-2.95)	-1.305 (-3.36)
Ad. Var.		EBUD	ETAX	EGOVC	EEXP	ERINTR	EINFL
		-0.337 (-2.63)	-0.565 (-2.45)	-0.362 (-3.16)	-0.180 (-1.65)	-0.003 (-0.31)	-0.0009 (-2.06)
R^2	0.38	0.43	0.40	0.43	0.41	0.37	0.43
Obs	96	72	90	96	96	86	96
JB	2.10	2.95	0.89	3.03	5.91	3.80	2.07
MDEPV	1.27	1.15	1.28	1.27	1.27	1.28	1.27
SDDEPV	1.93	2.20	1.90	1.93	1.93	1.90	1.93
F	20.60	14.60	15.89	19.06	17.57	13.36	17.24

Note: see Table 1.

Table 3: Stability Test Based on Base Model 1.

	R^2	Coef.	St. Error	CDF	High	Low	Perc.
EBUD	0.60	-0.267	0.110	0.993	0.408	-0.985	0.73
ETAX	0.58	-0.509	0.209	0.993	1.083	-1.963	0.86
EGOVC	0.59	-0.441	0.142	0.999	0.536	-1.565	0.90
EEXP	0.63	-0.382	0.090	1.000	0.205	-1.408	0.99
ERINTR	0.55	-0.019	0.014	0.909	0.121	-0.395	0.14
EINFL	0.54	-0.0649	0.126	0.699	4.904	-5.114	0.38

Note: R^2 : the average adjusted R^2 of all regressions. Coef: the average coefficient of all regressions; St. Error: the average standard error of all regressions; CDF: cumulative distribution function; High: the highest value for the coefficient plus 2 times the standard error; Low: the lowest value for the coefficient minus two times the standard error; Perc.: the percentage of all cases in which the coefficient for the uncertainty measure is significant at the 90% level.

Table 4: Stability Test Based on Base Model 2

	R^2	Coef.	St. Error	CDF	High	Low	Perc.
EBUD	0.52	-0.260	0.123	0.982	0.461	-0.989	0.64
ETAX	0.48	-0.480	0.223	0.978	1.183	-1.944	0.68
EGOVC	0.50	-0.337	0.170	0.976	0.643	-1.635	0.67
EEXP	0.51	-0.274	0.108	0.994	0.338	-1.348	0.58
ERINTR	0.48	-0.015	0.014	0.855	0.110	-0.406	0.13
EINFL	0.46	-0.0914	0.137	0.755	4.880	-5.842	0.37

Note: see Table 3.

Abstract

This paper investigates the effect of uncertainty on economic growth. We construct measures of export uncertainty, government policy uncertainty and price uncertainty to augment a growth model, and using econometric techniques we test for robustness of the effects of these measure on economic growth in a cross-section of 138 developing and developed economies during 1970-1995. The result clearly shows a robust and negative effect of uncertainty on economic growth. These results underline the importance of export stability and policy credibility.